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(54) Engine idle speed control using predicted torque converter load

(57) A method of controlling engine idle speed in a motor vehicle having an internal combustion engine and multi-ratio transmission when launched from a neutral idle rest condition is disclosed.

During vehicle launch from neutral idle operation a feedforward or predicted torque converter load is determined and other engine torque loads are added to the feedforward or predicted torque converter load to determine the engine output torque required to control engine idle speed and provide a smooth between transmission operating modes throughout the launch period.

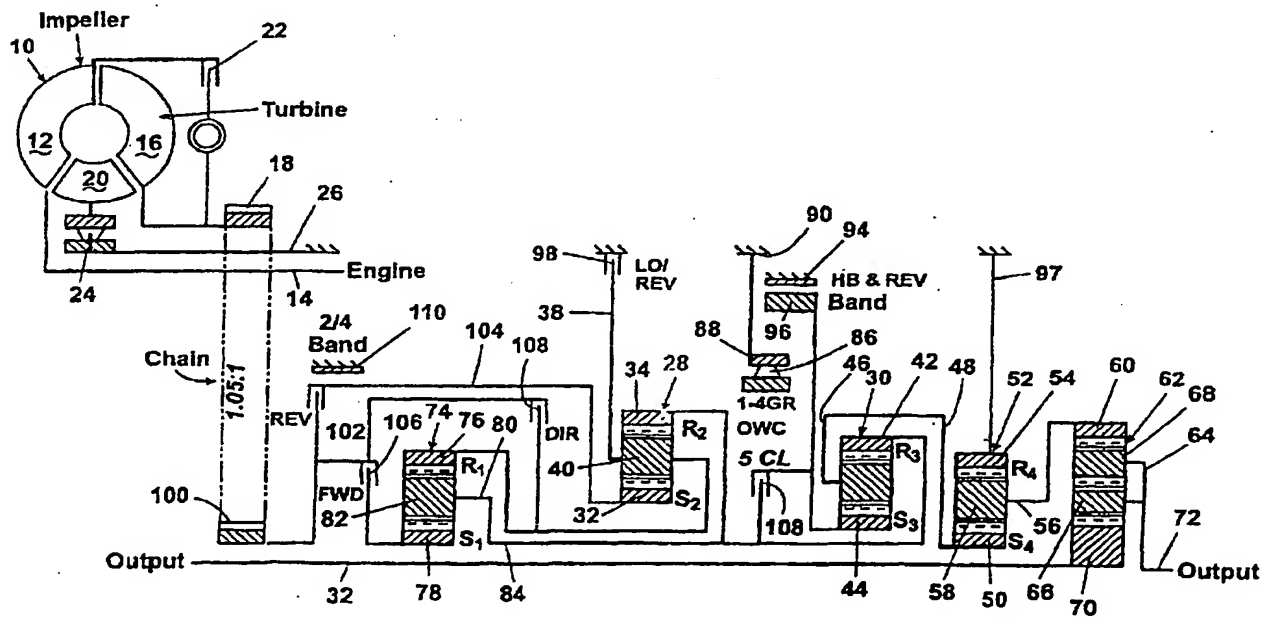

Fig. 1

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Description

[0001] This invention relates in general to a method of controlling engine idle speed in an automotive vehicle and in particular to a method of controlling engine idle speed when a forward clutch of a transmission is engaged upon releasing the service brakes during launch from neutral idle operation.

[0002] Neutral idle operation of a vehicle can be initiated when a vehicle is brought to a stand still position with the engine still running, as when a vehicle is stopped at a traffic light. In such situations, the transmission can be disengaged, i.e., neutral idle operation, which is beneficial to decrease overall vehicle fuel consumption by unloading the engine.

[0003] More technically speaking, neutral idle operation of a vehicle is generally characterised by the vehicle being at rest, the service brakes being applied, the gear select lever being in a forward range, and all combinations of torque transmitting clutches that establish a speed ratio from the input to the output member of the transmission being disengaged.

[0004] As a result, during neutral idle operation, the transmission input shaft rotates freely at a substantially synchronous speed with the engine output shaft.

[0005] When a vehicle begins to move after being held stationary, it is said that the vehicle is launching from neutral idle operation. One method of launching from neutral idle operation is for the vehicle operator to merely cease applying the service brakes and allow the vehicle to creep forward. The inventors herein have recognized that this type of slow launch from neutral idle operation sometimes causes the vehicle to exhibit undesirable noise, vibration, and harshness (NVH) during the launch. The undesirable NVH is primarily a result of the engine speed changing during the launch from neutral idle to accommodate and react to the increased engine load of the transmission upon re-engagement. Specifically, as the transmission's clutch pressure increases or decreases, the torque load on the vehicle's torque converter turbine, and therefore also on the impeller, also increases or decreases. As a result, the transmission's forward clutch begins to slowly engage to transfer the engine torque through the transmission, and the vehicle begins to slowly creep ahead. However, because conventional methods of engine speed control regulate the engine speed based on an assumption that the transmission is either in a "Drive" or "Neutral" mode of operation (as opposed to a partial mode in between "Drive" and "Neutral"), the engine speed control system tends to respond unevenly throughout the launch period. This is because the engine speed control system is reacting to the slowly increasing load on the engine.

[0006] Until recently, the NVH that results from the changing engine speed when the transmission engages has been relatively acceptable, primarily because vehicle operators have come to expect a certain amount of NVH when they physically move the vehicle's gear shifter from "Neutral" (or "Park") to a "Drive" position. However, because neutral idle operation is typically initiated by the vehicle itself, without the vehicle operator physically moving the gear shifter, the NVH that results from conventional engine speed control methods is more noticeable and undesirable.

[0007] According to a first aspect of the invention there is provided a method of controlling a vehicle having an engine coupled to a transmission through a clutch, comprising the steps of determining a predicted torque converter load based on a clutch torque capacity during launch from neutral idle operation and adjusting an engine operating parameter to limit output engine torque to said predicted torque converter load.

[0008] The method may further comprise the step of choosing a lesser of the predicted torque converter load and a maximum engine brake torque load.

[0009] The clutch may be a forward clutch or alternatively the clutch may be a reverse clutch.

[0010] The engine operating parameter may be a fuel injection amount.

[0011] Alternatively, the engine operating parameter may be an air intake amount.

[0012] According to a second aspect of the invention there is provided a method of controlling engine idle speed in a vehicle comprising the steps of determining a predicted torque converter load during launch from neutral idle operation and controlling engine torque output based on said predicted torque converter load.

[0013] The predicted engine brake torque load may be based on estimations of a clutch torque capacity.

[0014] The clutch may be a forward clutch.

[0015] Alternatively, the clutch may be a reverse clutch.

[0016] The engine torque output at a given time may be limited to the lesser of said predicted torque converter load and a maximum torque converter load.

[0017] According to a third aspect of the invention there is provided a method of controlling engine idle speed during launch from neutral idle operation comprising the steps of determining a maximum engine brake torque load; determining a predicted engine brake torque load and adjusting an engine operating parameter to limit output engine torque to the lesser of said maximum engine brake torque load and said predicted torque converter load.

[0018] The predicted torque converter load may be based on estimations of a clutch torque capacity.

[0019] The clutch may be a forward clutch.

[0020] The clutch may be a reverse clutch.

[0021] According to a fourth aspect of the invention there is provided system for transferring power from a vehicle

engine during launch from neutral idle operation, comprising a transmission including a torque input shaft, a torque output shaft, and a gear mechanism adapted to establish a torque flow path between the torque input shaft and the torque output shaft; a forward clutch for connecting the torque input shaft to the gear mechanism; and a microprocessor for determining a predicted torque converter load and controlling engine output torque based on said predicted torque converter load.

[0022] The predicted torque converter load may be based on a clutch torque capacity.

[0023] The clutch may be a forward clutch.

[0024] Alternatively, the clutch may be a reverse clutch.

[0025] The engine output torque may be limited by selecting the lesser of said predicted torque converter load and a maximum engine brake torque load.

[0026] According to a fifth aspect of the invention there is provided a system for controlling a vehicle having an engine coupled to a transmission through a clutch, characterised in that the system includes electronic means programmed to determine a predicted torque converter load based on a clutch torque capacity during launch from neutral idle operation and to adjust at least one engine operating parameter to control output engine torque based on at least said predicted torque converter load.

[0027] The clutch may be a forward clutch or may be a reverse clutch.

[0028] The at least one engine operating parameter may be controlled to limit output engine torque to said predicted torque converter load

[0029] The transmission may include a torque input means, a torque output means and a gear mechanism adapted to establish a torque flow path between the torque input means and the torque output means, a forward clutch for connecting the torque input means to the gear mechanism and a the electronic means is a microprocessor used to determine the predicted torque converter load and to control engine output torque based on at least said predicted torque converter load.

[0030] The predicted torque converter load may be based on a clutch torque capacity.

[0031] The engine output torque may be limited by selecting the lesser of said predicted torque converter load and a maximum torque converter load.

[0032] The engine operating parameter may be an amount of injected fuel or may be an intake air amount.

[0033] The invention will now be described by way of example with reference to the accompanying drawing of which:-

FIG. 1 is a schematic representation of a planetary gear transmission having a forward clutch located in the torque flow path between a hydrokinetic torque converter turbine and the input elements of the gearing;

FIG. 2 is a chart that shows a clutch and brake engagement and release pattern for the transmission shown in FIG. 1;

FIG. 3 is a schematic representation of the control system including the electronic microprocessor for controlling clutch engagement in a closed-loop fashion;

FIG. 4 is a graph that shows output torque and clutch pressure changes as well as the engine speed and turbine speed changes during a neutral idle condition and during a subsequent engagement of the forward clutch for a typical transmission of a prior art type;

FIG. 5 is flow diagram of controlling engine idle speed during neutral idle operation according to a first method of the invention; and

FIG. 6 is flow diagram of controlling engine idle speed during neutral idle operation according to a second method of the invention.

[0034] Referring now to the drawings, there is illustrated in Fig. 1, a hydrokinetic torque converter, shown generally at 10, which includes a bladed impeller 12 driveably connected to a vehicle engine crankshaft 14.

[0035] A bladed turbine 16 is connected to drive sprocket 18 of a chain transfer drive. A bladed stator 20 is located between the toroidal flow exit section of the turbine of the turbine flow entrance section of the impeller and acts in known fashion to change the direction of the toroidal fluid flow, thus making possible a torque multiplication in the torque converter 10.

[0036] During steady-state operation in higher gear ratios, a friction bypass clutch 22 may be engaged to driveably connect the impeller 12 and the turbine 16, thus effectively removing the hydrokinetic torque flow path from the driveline. Stator 20 is anchored against rotation in a direction opposite to the direction of rotation of the impeller by an overrunning brake 24, which is grounded to stator sleeve shaft 26.

ratio clutch 109 is identified as 5CL clutch, and brake band 110 is identified as 2/4 band.

[0055] First ratio drive is achieved by engaging brake band 94, which anchors sun gear 44. Also, disc brake 98 is applied, and forward clutch 106 is applied. Thus, sun gear 78 is connected to the driven sprocket at 100, and the underdriven motion imparted to the carrier 80 is transferred to the ring gear 42 of gear unit 30. In FIG. 2, brake band 94 is referred to as the HB and REV band. The reverse clutch 102 is identified in FIG. 2 as the REV clutch.

[0056] A schematic representation of a microprocessor control system, shown generally at 200, is shown in FIG. 3. The engine is generally designated by reference numeral 228.

[0057] Operating variables for the engine, such as manifold pressure and coolant temperature and engine speed, are measured by analog sensors and distributed to an electronic microprocessor 230. The signal passage for manifold pressure is shown at 232. The engine coolant temperature signal is distributed to the processor 230 through signal line 234. The engine speed signal is distributed to the processor 230 through line 236.

[0058] Other variables that are measured and distributed to the processor are a signal indicating the range selection or transmission manual valve position. This signal is distributed through signal passage 238. Turbine speed also is measured, and that value is distributed to the processor through signal line 240. The torque output shaft speed for the transmission is distributed to the processor through signal line 242. A bypass clutch pressure signal is distributed to the processor through signal line 244, but that signal is irrelevant to the present invention.

[0059] Transmission oil temperature for the engine is measured, and the signal representing that value is distributed to the processor through signal line 246. A brake signal is distributed to the processor through signal line 248. The presence of a signal at line 248 will indicate whether the vehicle brakes are applied or released by the vehicle operator.

[0060] The processor 230 will receive the information developed by the sensors and condition it so that it may be used in digital form by the central processor unit.

[0061] The central processor unit identified at 250 processes the information delivered to the processor 230 in a manner that will be described subsequently using algorithms that are stored in memory 252. The output signals from the processor 230 are delivered to a valve body 254 through signal line 256. The output data includes shift signals delivered to the shift solenoids that control the ratio changes. The operation of the valve body 254 and the solenoid signals are described in U.S. Pat. No 5,272,630.

[0062] The output signal developed by the valve body 254 delivered through signal line 258 controls the operation of the clutches and brakes of the transmission illustrated in FIG. 1.

[0063] For purposes of describing the benefits of the present invention, a comparison to prior art neutral idle characteristics will first be made with reference to FIG. 4, which shows a prior art neutral idle clutch characteristics for a transmission having an open loop-type converter.

[0064] This type of transmission is further described in U.S. Pat. No. 5,272,630. In FIG. 4, time is plotted on the abscissa; and output shaft torque, clutch fluid pressure, engine speed and turbine speed are plotted on the ordinate.

[0065] The forward clutch pressure, the engine speed, the turbine speed and the output shaft torque assume initially the values shown in region A of FIG. 4.

[0066] It is seen from FIG. 4 that the turbine speed is zero since the vehicle is at rest. The difference between engine speed and turbine speed represents the slip that exists when the vehicle comes to rest and before the neutral idle mode begins. At time B, the neutral idle mode is initiated, which results in an exhaust of pressure from the forward clutch. This results in a decay of the forward clutch pressure over a short period of time, as indicated by the curve C in FIG. 4. The output shaft torque decays, as shown by curve D, as the forward clutch pressure is relieved.

[0067] As the forward clutch looses capacity following initiation of a neutral start mode, the turbine speed will increase, as shown at E, until it reaches the normal turbine speed for engine idle, which may be 600 rpm as shown at F in FIG. 4. The engine speed at that time in a typical vehicle installation may be about 800 rpm as shown at G.

[0068] Figure 4 illustrates at point H what happens, according to the prior art, when the operator terminates the neutral idle mode by advancing the accelerator pedal. An immediate increase in the forward clutch pressure then will occur until a transition pressure indicated at I is reached. It is during this interval that the clutch servo cylinder is filling and the clutch servo piston is stroking. Because the engine throttle is advanced, the engine speed will respond to the advancing throttle and will increase as shown by the ramp J in FIG. 4. The engine speed continues to increase until the clutch servo is fully stroked. At that time, the engine speed will have reached a peak value shown at K.

[0069] When the piston for the forward clutch servo is stroked and the forward clutch gains capacity, the output shaft torque will sharply rise, as indicated by the steep slope curved portion L, until it reaches a peak value shown at M.

[0070] The achievement of the peak value M is coincident generally with the peak engine speed, the latter immediately decreasing in value at a fast rate, as shown at N. The decreasing engine speed is accompanied by a substantial inertia torque that contributes to the achievement of the peak value M for the output shaft torque. The clutch pressure will continue to increase following the stroking of the clutch servo piston and progressively increase at a rapid rate, as shown by the curve 0, until a final clutch pressure value is reached, as shown at P. The output shaft torque will be subjected to torque fluctuations, as demonstrated by the oscillating torque values Q following clutch engagement.

[0071] The control strategy of the present invention that avoids these undesirable features of the prior art will now

be explained with reference to FIG. 5.

[0072] Referring now to FIG. 5, the first preferred routine executed by microprocessor 230 for controlling engine idle speed during launch from neutral idle operation will now be described.

[0073] The vehicle begins in the neutral idle operating condition (step 500). As described above, the neutral idle operating condition results in an exhaust of pressure from the forward clutch at time B in FIG. 4. This results in a decay of the forward clutch pressure over a short period of time, as indicated by the curve C in FIG. 4. The output shaft torque decays, as shown by curve D, as the forward clutch pressure is relieved. As the forward clutch loses capacity following initiation of a neutral start mode, the turbine speed will increase, as shown at E, until it reaches the normal turbine speed for engine idle, which may be 600 rpm as shown at F in FIG. 4. The engine speed at that time in a typical vehicle installation may be about 800 rpm as shown at G.

[0074] At some point after being maintained in neutral idle operation for a period of time, the vehicle operator releases the service brakes {step 502). Though the present invention can be used in connection with a variety of types of launches from neutral idle, the present invention is particularly useful in situations where the vehicle operator does not immediately depress the accelerator pedal to terminate neutral idle operation, as shown at H in FIG. 4. Rather, the vehicle operator merely allows the vehicle to creep forward, which results in a relatively slow engagement of the transmission.

[0075] According to the present invention, the engine idle speed during launch can be controlled by predicting a feedforward engine torque and then controlling the engine speed based upon that prediction. The feedforward engine torque is that predicted engine torque that is expected to be necessary to accommodate the increased torque required by the re-engaging transmission at a point in time in the near future.

[0076] As used herein, the term "load" is a generic term that represents the amount of torque that the transmission exerts on the engine at a given time.

[0077] According to a first embodiment of the invention, the predicted required engine torque is limited to the minimum of an estimated torque converter load when the forward clutch is fully engaged (i.e: turbine speed equal to zero) and the predicted torque required by the re-engaging transmission. This is done to allow the forward clutch to engage at a desired rate while preventing excessive clutch slippage and engine flare. Therefore, the maximum torque converter load is calculated (step 504) according to the following expression:

Max_Converter_Tq_Load = Fn_Conv_Load (Ne, Nt and other transmission variables),
where:-

Ne is the engine speed,
Nt is the turbine speed and is assumed equal to zero,
and
Fn_Conv_Load converts engine speed and turbine speed to engine brake torque independent of whether the forward clutch is engaged.

[0078] Fn_Conv_Load is a function of engine speed, turbine speed and other transmission variables, such as transmission fluid temperature, temperature of the friction plates, slip across the clutch, clutch design, and the like.

[0079] Fn_Conv_Load is can be readily determined by one skilled in the art from relationships known to the skilled practitioner, namely the torque ratio function, Fn_Conv and a relationship that relates engine speed to the impeller torque.

[0080] The relationship between engine speed and impeller torque, otherwise known as the K-factor, can be expressed as:

$$K\ (\text{Turbine Speed}/\ \text{Engine Speed}) = \frac{\text{Engine Speed}}{\sqrt{\text{Im pellerTorque}}}$$

[0081] The numerical values for the K-factor can be determined empirically by one skilled in the art. The above equation can be rearranged as follows:

$$\text{Impeller Torque} = (\text{Engine Speed}/\ (K\ (\text{Turbine Speed}/\ \text{Engine Speed}))^2$$

[0082] The above equation exemplifies that the impeller torque can be determined based on engine speed and turbine speed. It will be appreciated that the determination of Fn_Conv Load may be further refined by one of skill in the art by taking into account other transmission variable, such as transmission fluid temperature, temperature of the

friction plates, slip across the clutch, clutch design, and the like.

[0083] Then, a predicted future turbine speed, Nt-Pred, is calculated based on the current turbine speed and a rate of change of the turbine speed (step 506), according to the following expression:

$$Nt_Pred = \max(Nt + Nt_Rate_Of_Change * Time_Into_Future, 0)$$

[0084] Next, as shown in step 508, the torque capacity of the forward clutch at any given time throughout the launch period is calculated using the following equation:

$$Forward_Clutch_Torque_Capacity = Fn_Cap\ (clutch\ pressure,\ other\ transmission\ variables)$$

where,

Fn_Cap converts either a commanded or measured forward clutch pressure into a torque capacity. Fn_Cap is a function of clutch pressure and other transmission variables, such as transmission fluid temperature, temperature of the friction plates, slip across the clutch, clutch design, and the like. Fn-Cap includes a conversion factor from torque measured at the forward clutch to torque measured at the turbine shaft and can be expressed as

$$Fn_Cap = m * Clutch_Pressure - b$$

where,

m and b are constants that are determined empirically by one skilled in the art.

[0085] Then, a feedforward or predicted torque converter load is determined (step 510) by the following expression:

$$Pred_Load_Torque = \frac{Forward_Clutch_Torque_Capacity}{Fn_Conv(Nt_Pred / Ne)}$$

where,

Fn_Conv is the torque multiplication or ratio of the torque converter and can be determined by one skilled in the art by plotting the torque ratio (turbine torque / engine torque) as a function of the speed ratio (turbine speed / engine speed). The numerical values for turbine speed and torque, and engine speed and torque can be determined empirically by one skilled in the art.

[0086] Next, the feedforward or predicted torque converter load is limited to the lesser of the maximum torque converter load and the predicted torque converter load (step 512). In terms of a mathematical expression, the predicted torque converter load is expressed as follows:

$$Conv_Tq_Load_Predicted = \min(Max_Converter_Tq_Load,\ Pred_Load_Torque)$$

[0087] Then, the actual engine torque for controlling engine idle speed is determined by adding any other engine torque loads to the feedforward or predicted torque converter load (step 514). Examples of other engine torque loads include, but are not limited to, engine accessories, such as air conditioning, pumps, and the like.

[0088] Finally, the vehicle microprocessor determines whether the vehicle's launch from neutral idle is complete. If so, the algorithm ends (step 516). If not, then steps 502-514 are repeated.

[0089] Referring now to FIG. 6, a second embodiment of a method in accordance with the invention will now be described. As in the first method, the vehicle begins in the neutral idle operating condition (step 600). At some point, the vehicle operator releases the service brakes (step 602) and allows the vehicle to creep forward, thereby causing the transmission to re-engage relatively slowly.

[0090] Then, as in the first preferred embodiment, a feedforward turbine speed, Nt_Pred, is predicted at a time in the future based on a current turbine speed and a rate of change of the turbine speed (step 604). The same expression as in the first preferred embodiment is used here:

$$Nt_Pred = \max(Nt + Nt\ Rate_Of_Change * Time_Into_Future, 0)$$

[0091] Unlike the first preferred embodiment though, the second preferred method calculates the feedforward or

predicted torque converter load in a continuous loop using the following expression (step 606):

$$Conv_Tq_Load_Predicted = Fn_Conv_Load\{Ne, Nt_Pred, Other\ Transmission\ Variables\}$$

where,
Ne is the engine speed,

$$Nt_Pred = \max(Nt + Nt_Rate_Of_Change * Time_Into_Future, 0)$$

and
Fn_Conv_Load is identical to the mathematical function having the same name described in connection with the first preferred embodiment.

[0092] The Fn_Conv_Load function converts engine speed and turbine speed to engine brake torque independent of whether the forward clutch is engaged and is a function of engine speed, turbine speed and other transmission variables, such as transmission fluid temperature, clutch design, and the like.

[0093] After the feedforward or predicted torque converter load is calculated, the actual engine torque required to control engine idle speed is determined by adding any other engine torque loads to the feedforward or predicted torque converter load (step 608).

[0094] Examples of other engine torque loads include, but are not limited to, engine accessories, such as air conditioning, pumps, and the like. Then, the microprocessor 230 determines whether the launch from neutral idle is complete. If so, the algorithm ends (step 610). If not, then steps 602-608 are repeated.

[0095] Unlike the first preferred embodiment of the invention, in the second method of the invention, the torque capacity of the forward clutch is not predicted and converted to an impeller torque as in steps 508 and 510 of the first method of the invention. Rather, the feedforward or predicted torque converter load is determined in a continuous loop.

[0096] Irrespective of which of the preferred methods is used, the present invention maintains a constant engine idle speed during launch and provides a smooth transition between transmission operating modes. This is accomplished by predicting the feedforward torque converter load to control engine torque throughout the launch period, unlike conventional methods. Then, the engine speed can be controlled by adjusting certain engine operating parameters, such as fuel injection amounts, air intake amounts, and other parameters known to those of skill in the art.

[0097] Although preferred embodiments of the present invention have been disclosed, a person of ordinary skill in the art will realise that certain modifications can be made without departing from the scope of this invention.

[0098] For example, the teachings of this invention apply when a different clutch other than the forward clutch or identified as the forward clutch is allowed to slip during neutral idle operation. Therefore, the following claims should be studied to determine the true scope and content of the invention.

Claims

1. A method of controlling a vehicle having an engine coupled to a transmission through a clutch **characterised in that** the method comprises the steps of determining a predicted torque converter load based on a clutch torque capacity during launch from neutral idle operation and adjusting an engine operating parameter to limit output engine torque to said predicted torque converter load.

2. A method as claimed Claim 1, further comprising the step of choosing a lesser of the predicted torque converter load and a maximum engine brake torque load.

3. A method of controlling engine idle speed in a vehicle **characterised in that** the method comprises the steps of determining a predicted torque converter load during launch from neutral idle operation and controlling engine torque output based on said predicted torque converter load.

4. A method as claimed Claim 3 wherein the predicted engine brake torque load is based on estimations of a clutch torque capacity.

5. A method as claimed Claim 7, wherein the engine torque output at a given time is limited to the lesser of said predicted torque converter load and a maximum torque converter load.

6. A method of controlling engine idle speed during launch from neutral idle operation **characterised in that** the method comprises the steps of determining a maximum engine brake torque load; determining a predicted engine brake torque load and adjusting an engine operating parameter to limit output engine torque to the lesser of said maximum engine brake torque load and said predicted torque converter load.

7. A method as claimed Claim 12, wherein the predicted torque converter load is based on estimations of a clutch torque capacity.

8. A system for transferring power from a vehicle engine during launch from neutral idle operation **characterised in that** the system comprises a transmission including a torque input shaft, a torque output shaft, and a gear mechanism adapted to establish a torque flow path between the torque input shaft and the torque output shaft; a forward clutch for connecting the torque input shaft to the gear mechanism; and a microprocessor for determining a predicted torque converter load and controlling engine output torque based on said predicted torque converter load.

9. The system of Claim 16, wherein said predicted torque converter load is based on a clutch torque capacity.

10. A method as claimed Claim 16, wherein said engine output torque is limited by selecting the lesser of said predicted torque converter load and a maximum engine brake torque load.

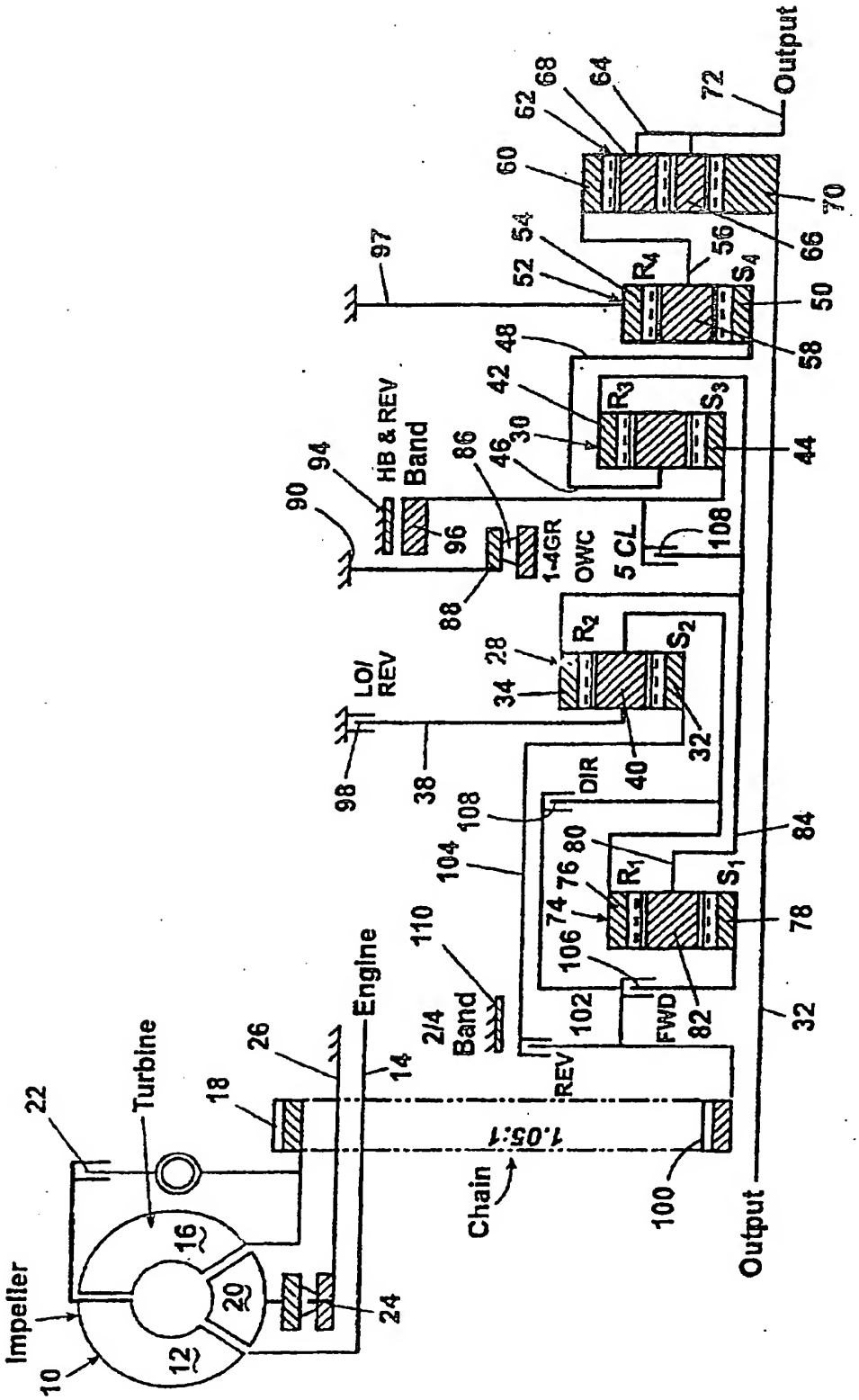
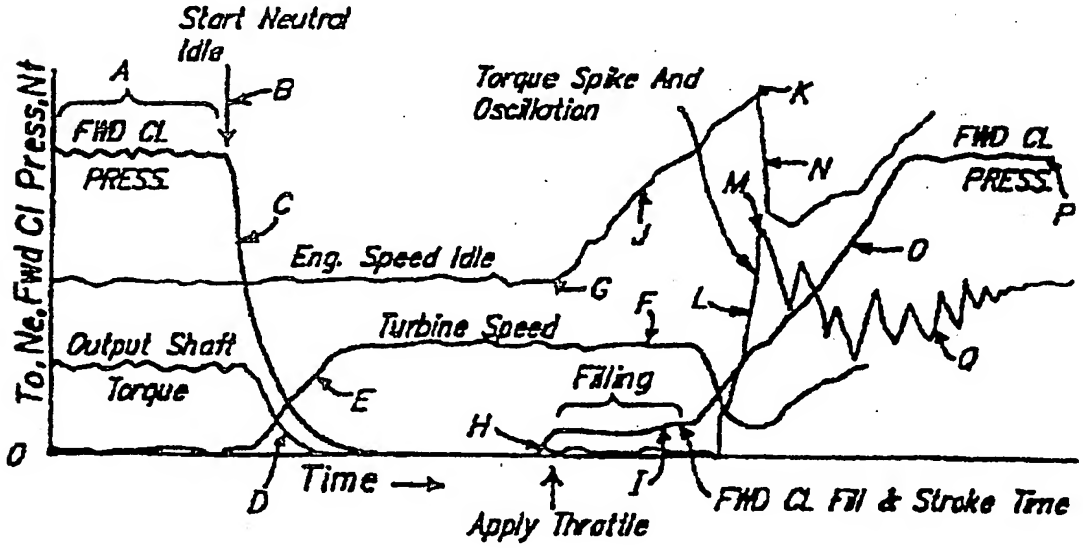

Impeller
Turbine
Engine
Chain
1.05:1
Output
HB & REV Band
2/4 Band
LO/ REV
DIR
REV
FWD
OWC
1-4GR
5 CL
R1
R2
R3
R4
S1
S2
S3
S4

Fig. 1

	REV	FWD	DIR	LO/ REV	SCL	2/4 BAND	HB & REV BAND	1-4GR OWC
1st		X		X			HB	X
2nd		X				X	HB	X
3rd		X	X				HB	X
4th			X			X	HB	X
5th			X		X	X		
REV	X			X			REV	

FIG. 2



Prior Art

FIG. 4

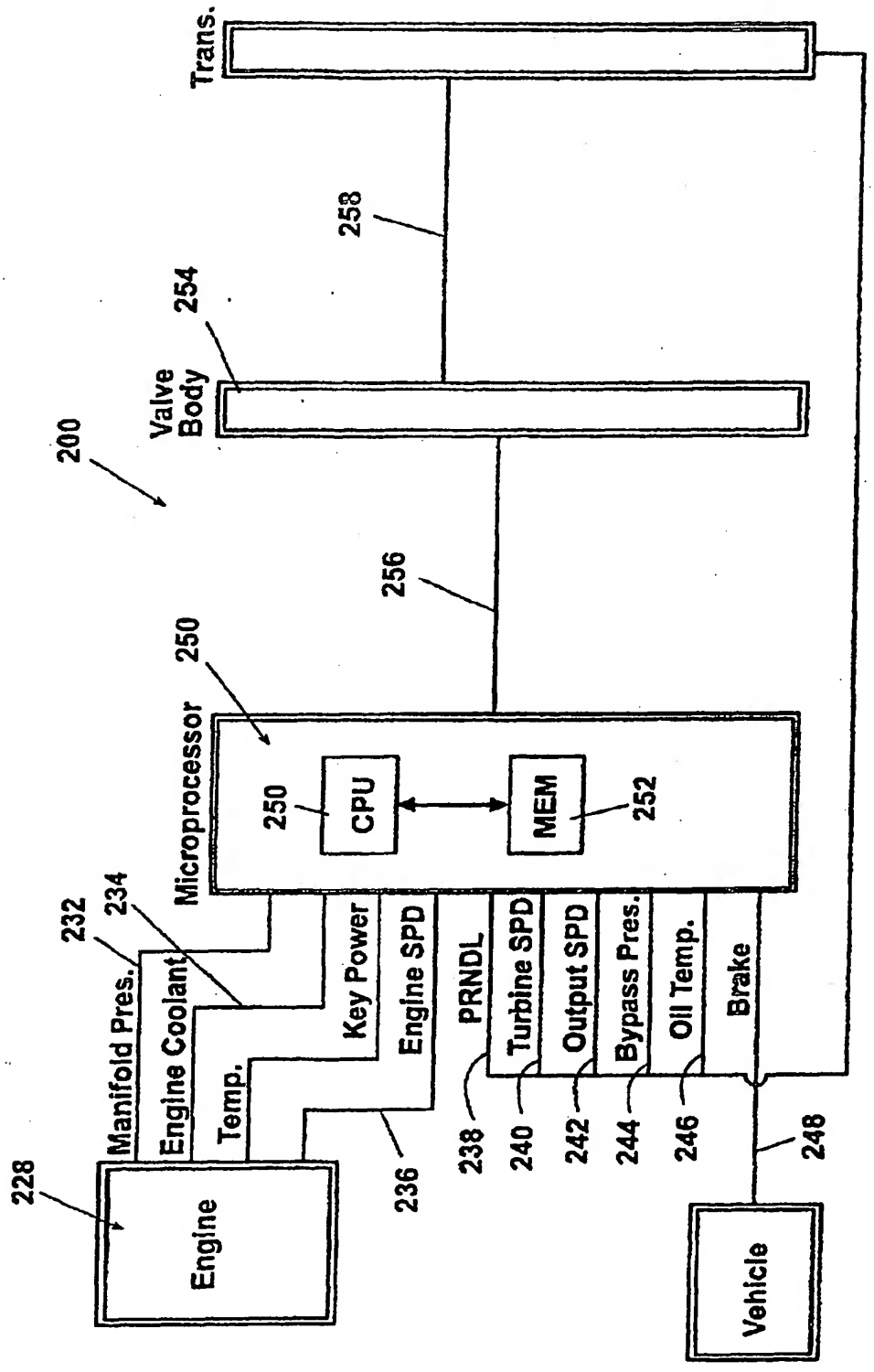

Trans.
258
254
Valve Body
200
256
250
Microprocessor
250
CPU
MEM
252
232
234
Manifold Pres.
Engine Coolant
Temp.
Key Power
Engine SPD
PRNDL
Turbine SPD
Output SPD
Bypass Pres.
Oil Temp.
Brake
228
Engine
236
238
240
242
244
246
248
Vehicle

Fig. 3

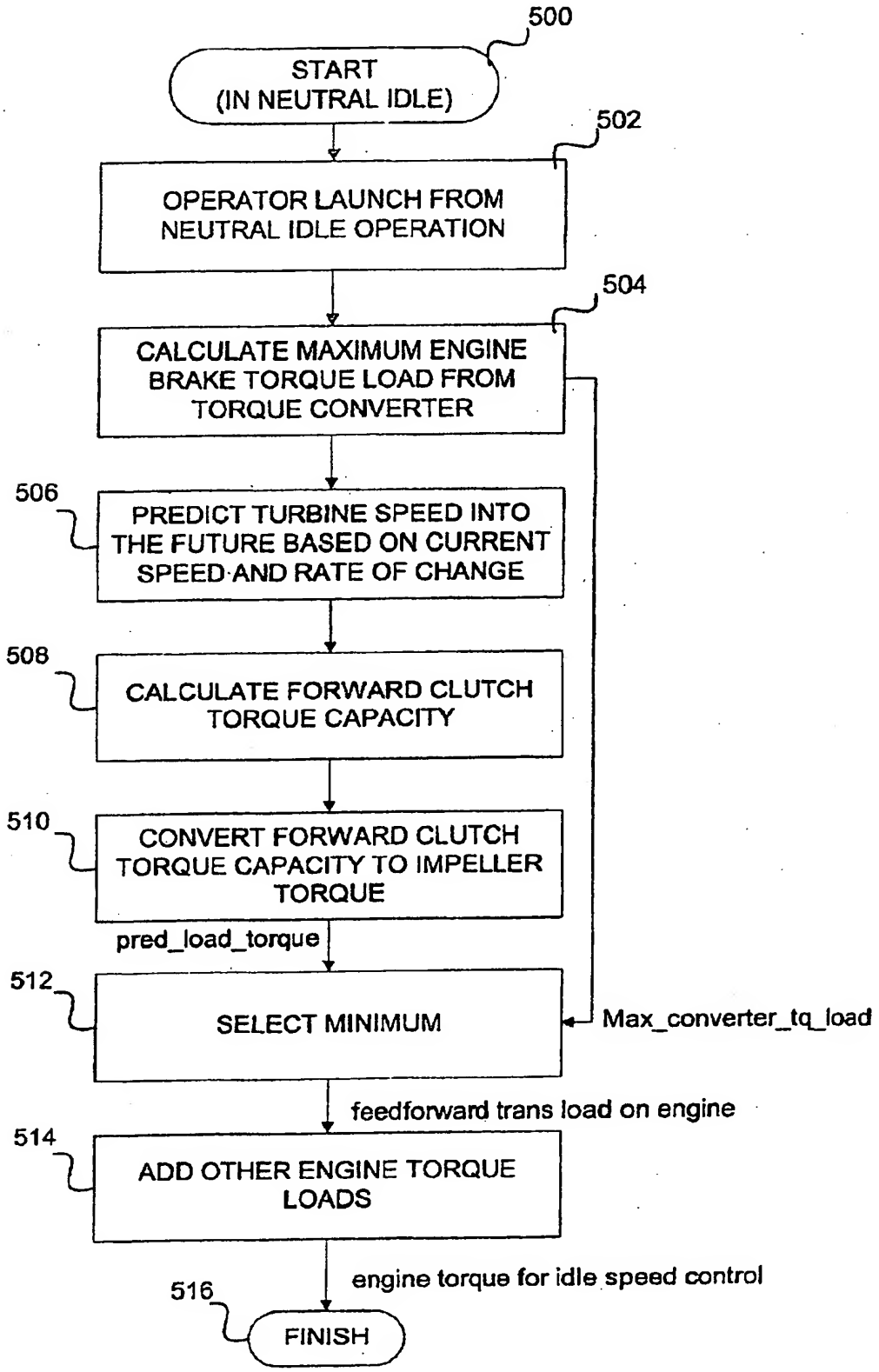

500
START
(IN NEUTRAL IDLE)
502
OPERATOR LAUNCH FROM NEUTRAL IDLE OPERATION
504
CALCULATE MAXIMUM ENGINE BRAKE TORQUE LOAD FROM TORQUE CONVERTER
506
PREDICT TURBINE SPEED INTO THE FUTURE BASED ON CURRENT SPEED AND RATE OF CHANGE
508
CALCULATE FORWARD CLUTCH TORQUE CAPACITY
510
CONVERT FORWARD CLUTCH TORQUE CAPACITY TO IMPELLER TORQUE
pred_load_torque
512
SELECT MINIMUM
Max_converter_tq_load
feedforward trans load on engine
514
ADD OTHER ENGINE TORQUE LOADS
engine torque for idle speed control
516
FINISH

FIG. 5

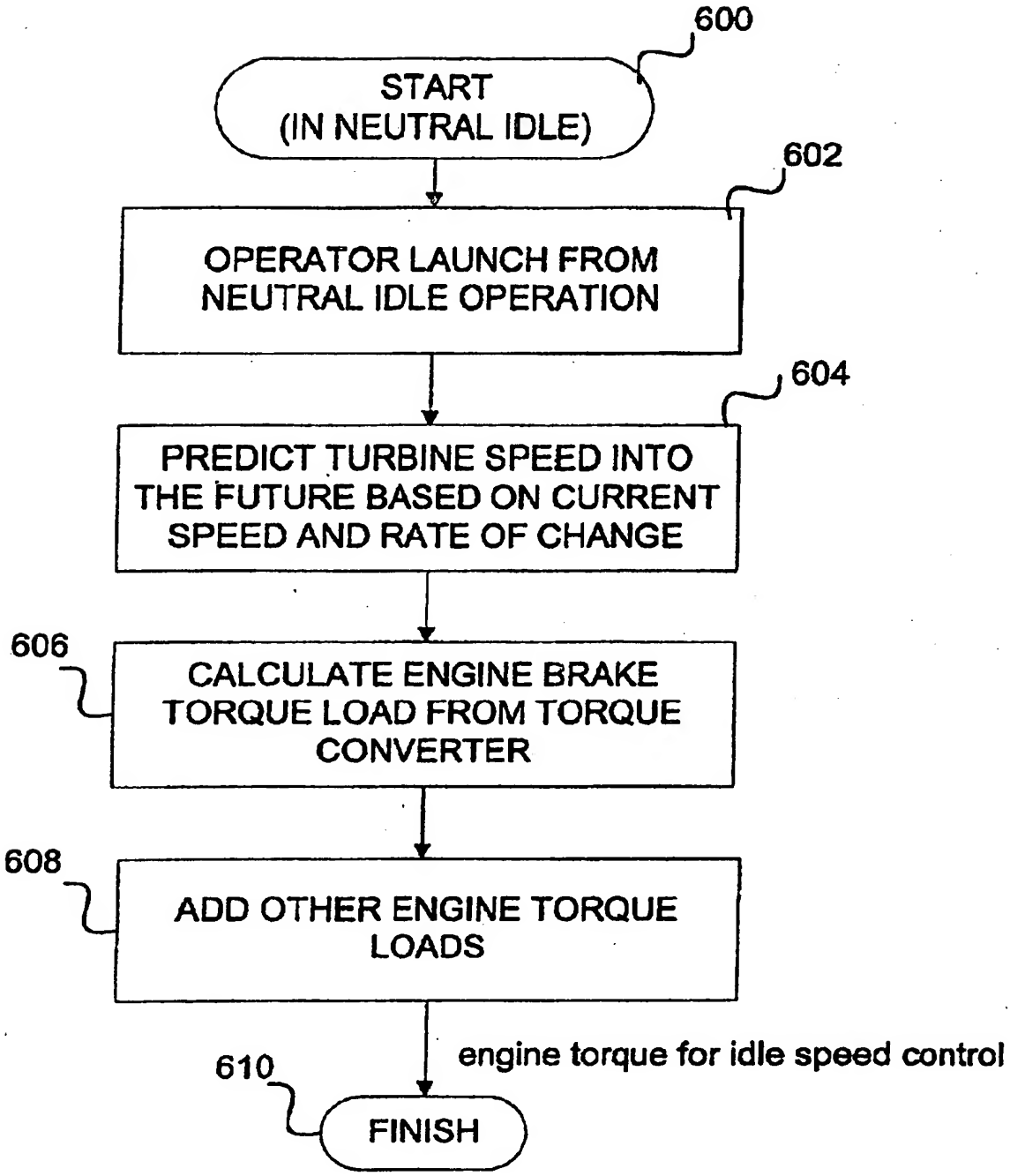

600
START
(IN NEUTRAL IDLE)
602
OPERATOR LAUNCH FROM
NEUTRAL IDLE OPERATION
604
PREDICT TURBINE SPEED INTO
THE FUTURE BASED ON CURRENT
SPEED AND RATE OF CHANGE
606
CALCULATE ENGINE BRAKE
TORQUE LOAD FROM TORQUE
CONVERTER
608
ADD OTHER ENGINE TORQUE
LOADS
engine torque for idle speed control
610
FINISH

FIG. 6